Spring 2022 EE214 Experiment 4
Impedance Measurement and Complex Power

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Contents

1 Introduction

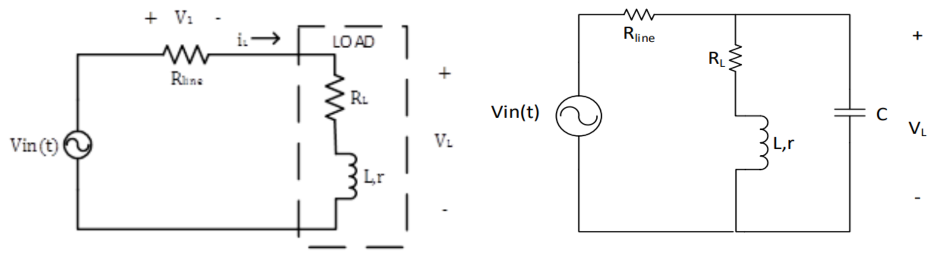
In this experiment, RMS values of voltages and currents will be measured, then the phase difference between current and voltage will be calculated, and complex power and power factor will be measured beside the apparent power S, the real power, and the reactive power with the efficiency of the system. Capacitance is aimed to be calculated using voltage and current RMS values. Afterward, two different modes of DSO will be used and explained to calculate impedance Z for different frequencies.

2 Experimental Results and Discussion

The results of the experiment are discussed in the following steps.

2.1 Step 1

In this part, circuit in figure 1 is set with $R_{line} = 100\Omega$ and $Z_{load} = 560\Omega + j0.1w$ and inductor $L = 0.1H$.



(a) (b)

Figure 1: Circuit schematic for the step 1

For the parts below (a-b-c), magnitude of the voltage source is adjusted such that $V_{load}(t)$ always equals to $5sin(2000\pi t)$ V.

2.1.1 a.

For this part, RMS values of V_{in}, V_{line}, V_{load}, i_{load} and phase difference between V_{load} and i_{load} are measured and recorded in table 1. RMS value of voltages is obtained by using the RMS measurement tool of DSO, and RMS current is obtained by measuring the voltage across 100Ω resistor. To calculate phase difference, the difference between peak values of the signals is measured in μs, and proportionality with the 1/frequency value is found.

Then, to find P_{line}, i_{load} is multiplied by V_{line} ,and power factor is found by using phase difference and found as cos(phase difference(54 deg)) leading. Afterwards, total apparent power on the load $|S|_{load}$ is found by multiplying i_{load} with V_{load} and recorded in table 2 and total real power on the load P_{load} is found by multiplying $|S|_{load}$ with power factor($cos(54\,\text{deg})$) and recorded in table 2. Then, total reactive power on the load Q_{load} is found by multiplying $|S|_{load}$ with $sin(54\,\text{deg})$ and noted in table 2.

2.1.2 b.

In this part, the 100nF capacitor is connected parallel with the load, and the same measurements and calculations with part a. are made. Then, the results are recorded in Table 1 and Table 2.

2.1.3 c.

For this part, the one μF capacitor is replaced with the 100nF capacitor in part a., and the same calculations and necessary measurements are made for this part as well.

2.1.4 d.

All the results of the measurements are given in this section as tabulated in Table 1 , 2 and 3.

Table 1: Power Measurements

Part	V_{in}(Vrms)	V_{line}(Vrms)	V_{Load}(Vrms)	i_{Load}(mArms)	ϕ_{Load}(degree)	ϕ_{in}(degree)
a.	3.7	0.4	3.4	4	65	
b.	3.7	0.3	3.41	3	40	
c.	4	1.6	3.4	16	-74	

Table 2: Power Calcuations

Part	P_{in}(mW)	P_{line}(mW)	P_{Load}(mW)	Q_{Load}(mVAR)	$\|S\|_{Load}$(mVA)
a.					
b.					
c.					

Table 3: Load Parameters

Part a. (Load)			Part b. Load			Part c. Load		
pf	lead/lag	eff %	pf	lead/lag	eff %	pf	lead/lag	eff %

2.2 Step 2

In this step, the circuit in figure 2 is set by adjusting signal generator output to a sine wave with 500 Hz frequency and 6 Volt peak to peak voltage value using one μF capacitor and one $k\Omega$ resistor to obtain current. Then, the RMS value of the voltage V across the capacitor is measured as 1.23 V, and the RMS value of the current passing through the capacitor is measured as 3.70 mA. Afterward, by doing the following calculations, capacitance C1 is calculated:

$$\frac{V_{rms}}{i_{rms}} = |Z| = \frac{(-j)^2}{w^2C^2}$$

where Z is the impedance and w = $2\pi(500Hz)$.

$$C1 = \frac{i_{rms}}{V_{rms}\omega} = \frac{3.79mA}{1.23V.1000\pi} \approx 0.98x10^{-6} = 0.98\mu F$$

Then by adjusting LC meter to proper scale, nominal capacitance of the capacitor is measured as 1.03 μF

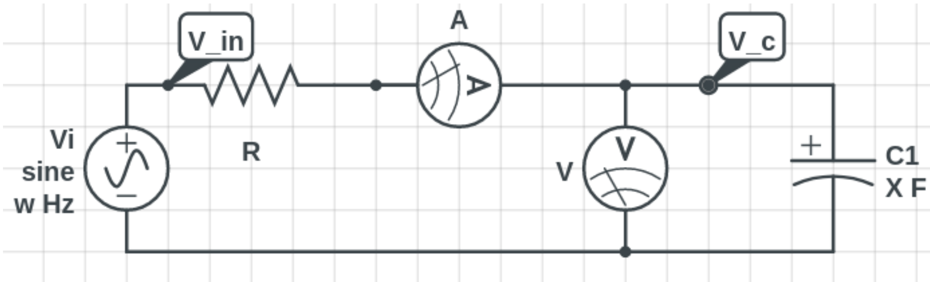


Figure 2: Circuit schematic for the step 2

2.3 Step 3

In this step, the circuit in figure 4 is set with 1.5 kHz and 3 kHz frequency sine wave, respectively, and 0.1 μF capacitor and 1kΩ resistor and 0.1 H inductor are used, then by using two different methods, impedance Z in Figure 3 is measured. To be able to measure , A and B terminals of the load is connected to the A and B terminals of the circuit given in Figure 4.

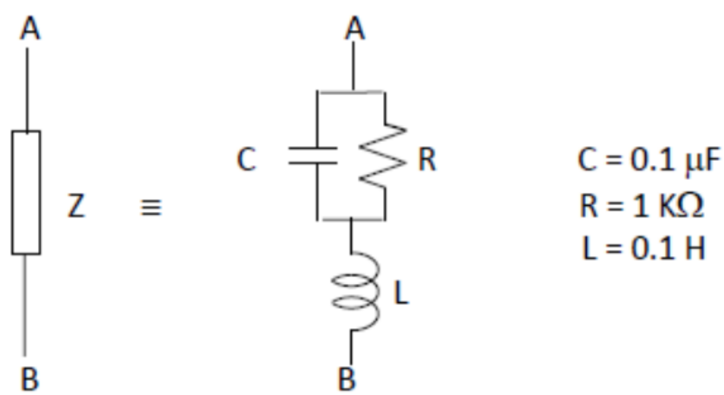


Figure 3: Circuit schematic for the step 3

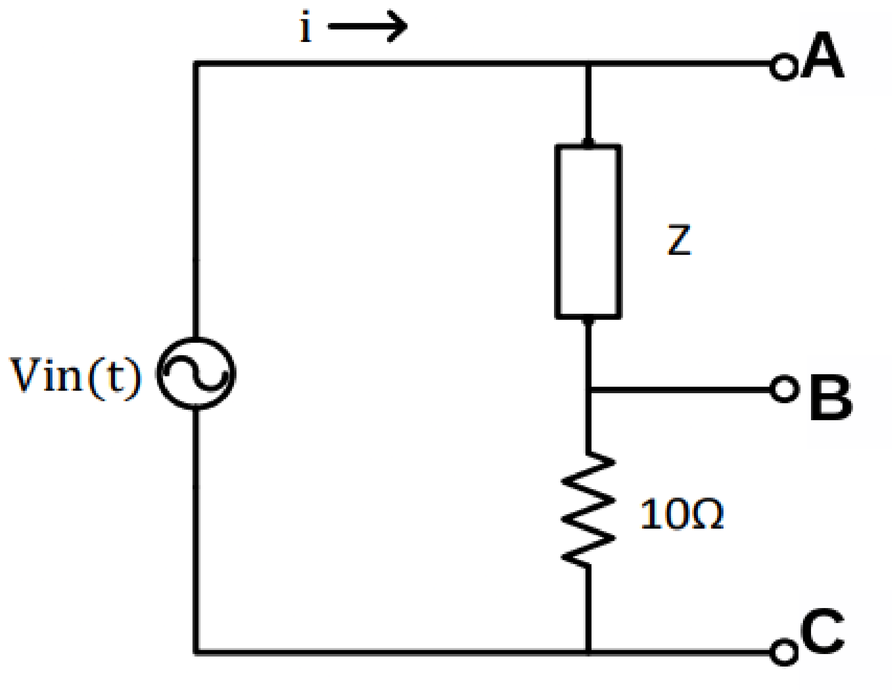


Figure 4: Outside circuit schematic for the step 3

2.3.1 First Method

In the first method, the probes of the oscilloscope is connected to the A, B and C terminals as follows. Terminal A is connected to the CH1, and Terminal C is connected to the CH2. Terminal B is connected to the common ground. Then the adjustment is made that CH2 is inverted in the oscilloscope. So, the CH2 corresponds to the current flowing through the circuit.
By ignoring the resistance of the 10 Ohm resistor, the phase angle is measured in XY mode.

2.3.2 Second Method

In the second method, setup described in the first method is conserved but instead of XY mode the time mode of the DSO is used. Here, simply the measure feature of the DSO is used and the same results are obtained. The results of the measurements made in Step 3 is given in Table 4, and Table 5.

Table 4: Power Measurements in Step 3 (1.5kHz)

CH1 (Voltage)	CH2 (mAmps)	Phase Angle (degrees)	Impedance (Ohms)
4	5	40	800

Table 5: Power Measurements in Step 3 (3kHz)

CH1 (Voltage)	CH2 (mAmps)	Phase Angle (degrees)	Impedance (Ohms)
4.2	2.7	80	1555

3 Conclusion

In this experiment, RMS values of voltages and currents are measured. Phase differences between current and voltage are calculated, and complex power and power factor are measured beside the apparent power S, the real power, and the reactive power with the efficiency of the system. Capacitance is calculated using voltage and current RMS values. Lastly, two different modes of DSO are used and explained to calculate impedance Z for two different frequencies.

Appendix A

- PreLab Preparation 3 hours
- Experimental Work 2 hours
- Report Writing 8 hours